Appendix E

Holistic Watershed Approach
Protocol for Integrated Watershed Characterization

Background

Integrated watershed characterizations produce better environmental data and information to make more informed decisions about where and how we invest our resources toward watershed management of mine drainage pollution and associated Total Maximum Daily Load (TMDL) implementation. Involving local, state, and federal agencies; industry; academia; and the public in planning and sampling for watershed characterizations, has led to effective protection, restoration, and enhancement of the ecological integrity of water quality and quantity. Time, costs, knowledge, skills, and abilities are some of the limiting factors when attempting to perform these tasks separately for the desired ecological integrity. Inconsistencies in planning, sampling, and data collection methodologies create quality assurance and quality control concerns. A standard operating procedure, or protocol, eliminates these inconsistencies. Implementation of a protocol, in an integrated fashion, reduces limitations and promotes outreach, education, and training, as well as improves knowledge, skills, and abilities. The West Virginia Division of Environmental Protection's Stream Restoration Group currently implements a Holistic Watershed Approach Protocol involving diverse stakeholders in planning and sampling for integrated watershed characterizations in six of West Virginia's thirty-two hydrologic regions. The Protocol is a dynamic document continually evolving to accommodate multiple applications and satisfy specific needs of diverse stakeholders.

Methodology

When a watershed is designated for watershed characterization to determine impairment from mine drainage pollution discharges, the *study area* watershed boundaries are determined and stakeholders are notified. Watersheds are defined based on the USGS-developed hydrologic unit cataloging (HUC) system. Stakeholder involvement, spearheaded by watershed organizations, is incorporated into all aspects of watershed characterizations, including: restoration, protection, and enhancement.

With the assistance of the stakeholders, a *comprehensive sampling network* is established, mapped, and staked. This *network* includes sampling locations that divide the mainstem into segments representing changes in water quality from upstream to downstream. Sampling locations at the mouth of all mainstem tributaries along with extensive sampling locations throughout the tributary stream reach are also included. Water quality and quantity measurements are obtained three to six times, spanning a range of hydrologic and climatologic conditions. Benthic macroinvertebrate surveys and fish surveys at selected locations are also collected during this time period.

If the watershed is large and dendritic, additional sampling of a *streamlined sampling network* is conducted. This consists of sampling locations of the mainstem and all the mainstem tributaries at the mouth locations only.
The environmental data and information is reviewed and mainstem tributaries are prioritized according to degree of impairment. A *focus area sampling network* of a selected mainstem tributary is then established and mapped. The *network* consists of

sampling locations at the pollution sources as well as at various locations throughout the mainstem tributary reach. Sampling locations are determined by researching existing data and field reviewing the area for all sources of mine drainage pollution discharges. As with the *comprehensive sampling network*, water quality and quantity measurements are obtained three to six times, spanning a range of hydrologic and climatologic conditions. Benthic macroinvertebrate surveys are also collected during this time period.

The data is reviewed and utilized for: establishing the impact of the mine drainage pollution sources to the *focus area* tributaries, selecting the most feasible pollution sources within the *focus area* to address, and identifying the best available technology for the abatement or treatment of the pollution sources.

Following mine drainage pollution remediation of selected project sites within the *focus area*, a *post construction sampling network* is established. It consists of the same *focus area* locations sampled prior to construction, in addition to the treated discharges resulting from the installation of any mine drainage pollution abatement technologies. All new sampling site coordinates are obtained and mapped. Three to six water quality and quantity sampling sweeps are conducted spanning a range of hydrologic and climatologic conditions. Benthic macroinvertebrate surveys are also collected during this time period.

This process continues until all *focus areas* in the initial *study area* have been addressed, and all feasible treatment or abatement technologies applied. At that time, three to six water quality and quantity sampling sweeps of the initial *comprehensive sampling network* are conducted spanning a range of hydrologic and climatologic conditions. Benthic macroinvertebrate surveys and fish surveys are also collected during this time period.

Results are analyzed and a report prepared evaluating the effect of the abatement or treatment technologies on the mine drainage pollution sources and their receiving streams.

Once implemented, the Protocol is a perpetual cycle with many overlapping process steps. The Protocol outline and a process flowchart is presented below:

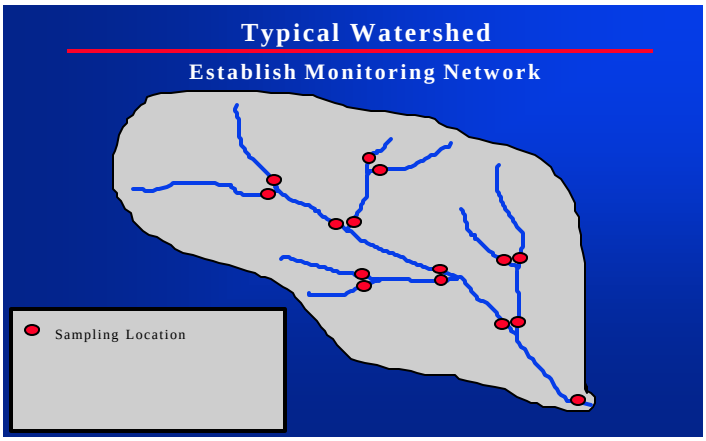
Holistic Watershed Approach Protocol

I. Define the *study area* and stakeholders.

- Select mainstem stream.
- Delineate watershed boundary.
- Foster Stakeholders.

II. Establish *comprehensive sampling network* within the *study area*.

- Select and number stream sampling stations utilizing USGS 7.5 Minute Topographic Quadrangle Maps and field reconnaissance.
  - Select mainstem stream sampling stations representing mainstem stream segments.
  - Select all mainstem tributary sampling stations at the mouth locations and at extensive locations throughout the mainstem tributary stream reach.



III. Geo-reference *comprehensive sampling network* for input into Geographical Information Systems (GIS).

IV. Implement sampling sweeps of the *comprehensive sampling network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
  - Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
  - Perform field measurements.
    - Obtain insitu water quality measurements at all sampling stations.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November.
  - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
  - Perform fish survey at selective stream sampling stations only.

V. Review all data collected. (If watershed is large and dendritic, continue or otherwise skip to IX.)

- Analyze changes in tributary and mainstem stream segments and compare tributaries.
  - Represent *Water Quality Study* data graphically.
  - Compare *Biological and Physical Study* data.

VI. Establish *streamlined sampling network* within the *comprehensive sampling network*.

- Select and number stream sampling stations.
  - Select mainstem stream sampling stations representing mainstem stream segments.
  - Select all mainstem tributary sampling stations at the mouth locations only.

VII. Implement sampling sweeps of *streamlined sampling network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
  - Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
  - Perform field measurements.
    - Obtain insitu water quality measurements at all sampling stations.
    - Obtain stream flow.

VIII. Review all data collected.

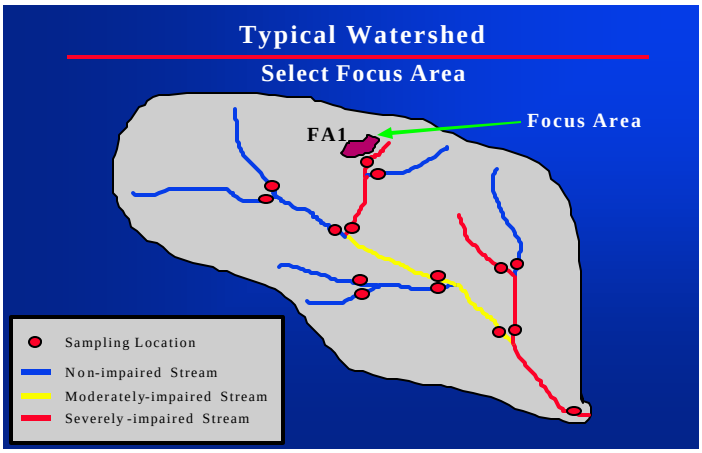
- Analyze changes in tributary and mainstem stream segments and compare tributaries.
  - Represent *Water Quality Study* data graphically.
  - Compare *Biological and Physical Study* data.
  - Compare mainstem tributaries with respect to degree of impairment.

IX. Define *focus study area*.

- Select impaired tributary within *comprehensive sampling network* and determine watershed boundary.

X. Establish *focus area sampling network* within the *focus study area*.

- Locate mine drainage pollution discharge sampling stations within impaired tributary watershed.
  - Research existing data.
  - Field review entire impaired tributary watershed.
- Select impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of mine drainage pollution discharge influx.
- Select receiving stream sampling stations upstream and downstream of the confluence with the impaired tributary.



XI. Geo-reference *focus area sampling network* for input into Geographical Information Systems (GIS).

XII. Implement sampling sweeps of *focus area sampling network*.

- Conduct *Water Quality Study* sweeps two to three times spanning a range of hydrologic and climatologic conditions.
  - Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
    - Collect pollution source water sample at origin. (When several sources co-mingle, it is necessary to collect a sample of the combined discharge.)
  - Perform field measurements.
    - Obtain insitu water quality measurements at all sampling stations.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November.
  - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of mine drainage pollution discharge project areas.

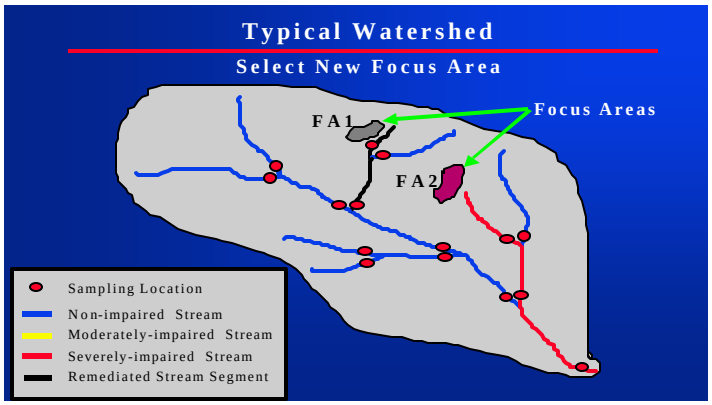
XIII. Review all data collected.

- Analyze *focus area sampling* network data.
  - Determine extent of impairment mine drainage pollution discharge contributes to the *focus area* impaired tributaries.
  - Determine site-specific mine drainage pollution discharge treatment technology for the sources at each project area.
    - Evaluate chemical suitability of selected mine drainage pollution discharge treatment technology.

- Evaluate physical suitability of selected mine drainage pollution discharge treatment technology.
- Determine in-stream mine drainage pollution discharge treatment technology for stream benefits in addition to, or in lieu of site-specific pollution discharge treatment.

XIV. Modify *focus area sampling network*. [If additional data is or may be required to support pre construction design(s), repeat XII through XIII.]

- Cease sampling of any portion of project for which polluted water abatement appears infeasible.
- Incorporate sampling of any additional *focus area(s)* mine drainage pollution discharges found following completion of **XII**.



XV. Report findings.

- Prepare preliminary pre-design *Water Quality Study* report.

Implementation

XVI. Establish *post construction focus area sampling network* when mine drainage pollution discharge treatment is complete in the *focus study area*. (If initial *study area* contains other *focus study area(s)* that have not been addressed, repeat IX through XV, otherwise continue.)

- Locate constructed mine drainage pollution discharge treatment systems within treatment project boundaries.
  - Field review mine drainage pollution discharge treatment project site.
- Select and number stream sampling stations throughout *focus study area*.
  - Select the previously impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of mine drainage pollution discharge treatment project influx.

- Select receiving stream sampling stations upstream and downstream of the confluence with the previously impaired tributary.

XVII. Geo-reference *post construction focus area sampling network* for input into Geographical Information Systems (GIS).

XVIII. Implement sampling sweeps of *post construction focus area sampling network*.

- Conduct *Water Quality Study* sweeps monthly during the first year period; quarterly during the second year period; and semiannually during the third and every subsequent year period spanning a range of hydrologic and climatologic conditions.
  - Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
    - Collect untreated source water sample at origin if possible.
    - Collect treated source water sample at mine drainage pollution discharge treatment system outflow.
  - Perform field measurements.
    - Obtain insitu water quality measurements at all sampling stations.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November, at least one year after completion of project construction.
  - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of mine drainage pollution discharge treatment project influx.

XIX. Implement sampling sweeps of the *comprehensive sampling network*. (If mine drainage pollution discharge treatment is complete throughout initial *study area* continue.)

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
  - Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
  - Perform field measurements.
    - Obtain insitu water quality measurements at all sampling stations.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November.
  - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
  - Perform fish survey at selective stream sampling stations only.

XX. Review all data collected.

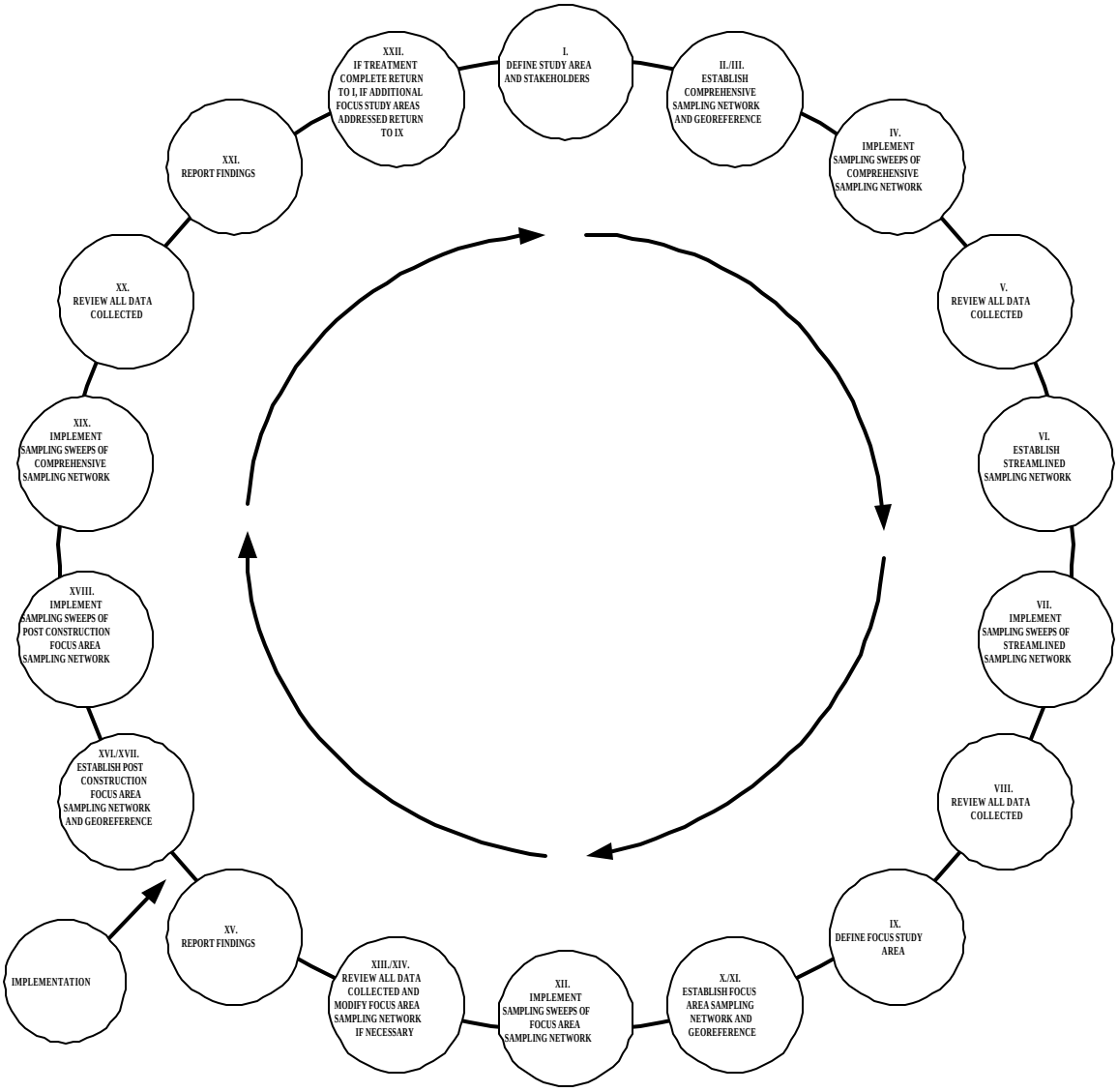
- Analyze changes in stream water quality.
- Analyze effectiveness and efficiency of constructed mine drainage pollution discharge treatment systems.
- Determine the effect of constructed mine drainage pollution discharge treatment systems on the mine drainage pollution discharges, *focus area sampling networks,* and *comprehensive sampling network*.

XXI. Report findings

- Prepare final post construction *Water Quality Study* report.

XXII. If mine drainage pollution discharge treatment is complete throughout the *study area,* return to I. If additional *focus study areas* will be addressed within the *study area,* return to IX.

Holistic Watershed Approach Protocol



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